

Claims

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1. Apparatus for determining the remineralization ability of hard tissue, in particular carious dental tissue, characterized by a measuring device (46, 60, 86, 88; 104, 114, 116, 86, 88; 130-140, 88; 144-148, 88; 150-154, 88; 156, 86, 88; 158-174), for local measurement of at least one of the following physical, chemical or biological tissue properties: porosity, hardness, light absorption and light reflection, sound absorption and sound reflection, cellular structure, electrical conductivity, chemical changes in the tissue framework or chemical changes in fluid present in the tissue framework, invasion by bacteria.
  2. Apparatus according to Claim 1, characterized in that the measuring device has a measuring head (40) with a rod-like, preferably cylindrical probe section (42) which comprises a measuring element (46, 60; 104, 116; 130, 134, 138; 144, 148; 150-154; 156; 158-170) responding to the physical, chemical or biological properties.
  3. Apparatus according to Claim 2, characterized by a position indicator (48-52) for the axial position of the probe section (42) in relation to a contour surface of the tissue.
  4. Apparatus according to Claim 3, characterized in that the probe position indicator (48-52) has an input part (48) which cooperates with the tissue surface and which is arranged axially displaceably on the probe section (42) and is supported by a spring (50) on a stationary apparatus section, to which spring a force or deformation sensor (52) is assigned.
  5. Apparatus according to Claim 4, characterized by an evaluation unit (88) which receives the output signal of the probe position indicator (48-52) and the output signal of the measuring element, and compares the output signals from the latter, which are obtained when the position of the probe section (42) differs, with one another, for which purpose the measured

signals obtained for each of the different probe positions are stored as a function of the output signal from the probe position indicator (48-52).

6. Apparatus according to any of Claims 2-5, where  
5 the measuring element has a radial measuring axis, relative to the axis of the probe section (42), characterized in that the probe section (42) is arranged rotatably (118-122) on the measuring head (40).

10 7. Apparatus according to any of Claims 2-6, characterized in that the measuring head (40) is attached to a grip part (36), with it preferably being rotatable about its long axis.

8. Apparatus according to Claim 7, characterized  
15 in that the long axis of the grip part (36) and the axis of the measuring head (40) are inclined with respect to one another and preferably include an angle between about 30° and about 90°, once again preferably of about 60°.

20 9. Apparatus according to Claim 7 or 8, characterized in that the grip part (36) is connected via a rotating joint (99) to a supply cable (101).

10. Apparatus according to any of Claims 1-9,  
25 characterized in that the measuring device has a first sensor part (104; 130, 138; 144; 150-54; 158, 160) acting on the tissue and a second sensor part (116; 130, 134; 148; 150-154; 164-170) measuring the response of the tissue to the stimulus, and in that means for adjusting the strength of the action produced by the  
30 first sensor part are provided.

11. Apparatus according to Claim 10, characterized in that the adjusting means comprise an input device (94) carried by the grip part (36).

12. Apparatus according to Claim 10 or 11, charac-  
35 terized in that the adjusting means comprise a program control (88).

13. Apparatus according to Claim 12, characterized in that the program control operates so that the acting sensor part (104; 130, 138; 144; 150-54; 158, 160) is

stimulated so that a preset output signal is obtained at the recording sensor part (116; 130, 134; 148; 150-154; 164-170).

14. Apparatus according to any of Claims 2-13, characterized in that the measuring head (40) has a sealing element (54) which cooperates with a section of the tissue surface, and in that the measuring head (40) is connected to a fluid source (76; 80) which is under a pressure different from normal pressure, and the measuring device measures the fluid leakage through the tissue to be investigated.

15. Apparatus according to Claim 14, characterized in that the fluid is a gas and in that the measuring head (40) can be connected via an on-off valve (62) which has a closed position to the fluid source (76; 80), and a pressure gauge (60) is connected to the measuring chamber which is limited by the measuring head (40) and the tissue.

16. Apparatus according to Claim 15, characterized in that the measuring head (40) has a pressure reservoir (58) connected to the measuring chamber.

17. Apparatus according to Claim 14, characterized in that the diagnostic fluid is a liquid and in that a flow meter (66) is arranged in the supply line leading from the fluid source (76) to the measuring head (40).

18. Apparatus according to Claim 17, characterized in that the flow meter (66) has a capillary tube and means for feeding gas bubbles into the downstream end of the capillary tube.

19. Apparatus according to any of Claims 14-18 in conjunction with Claim 4, characterized in that the sealing element (54) is carried by the free front surface of the input part (48) of the probe position indicator (48-52).

20. Apparatus according to any of Claims 14-18 in conjunction with Claim 2, characterized in that the probe section (42) is a cylindrical pipe which is closed at the end (44) and which has at least one fluid emergence orifice in its peripheral wall.

21. Apparatus according to Claim 20, characterized in that the probe section (42) has at its end remote from the free end a preferably conical shoulder (274) which expands in the radial direction, and in that a  
5 sealing tube (276) is arranged on the outside of the probe section (42) and can be pushed with its end which is remote from the free end of the probe section (42) onto the sealing shoulder (274) with widening.

22. Apparatus according to any of Claims 14-21,  
10 characterized in that the measuring head (40) can be connected by a reversing valve (72) alternately to a positive pressure fluid source (76) and a negative pressure fluid source (80).

23. Apparatus according to Claim 22 in conjunction  
15 with Claim 17, characterized by means (102) for collecting the liquid volume aspirated from the measuring head (40).

24. Apparatus according to any of Claims 1-13, characterized in that the measuring head (40) has a  
20 measuring point (104) which can be extended.

25. Apparatus according to Claim 24 in conjunction with Claim 2, characterized in that the measuring point (104) is carried by a lever (108) which can be pivoted by an actuating rod (112) running in the lengthwise  
25 direction of the probe section (42) so that the measuring point (104) is moved with a radial movement component through a window (106) of the probe section (42).

26. Apparatus according to Claim 24 in conjunction  
30 with Claim 2, characterized in that the measuring point is carried by a flexible transmission element (124) which is guided in a guide (126) in the probe housing (128) so that the transmission element (124) emerges with a radial direction component from the probe  
35 housing (128).

27. Apparatus according to Claim 25 or 26, characterized in that the actuating rod (112) is moved by a motor operator (114) whose driving force is adjustable (74).

28. Apparatus according to any of Claims 1-13, characterized in that the measuring head (40) comprises a light source (138), an optical system (130, 132) and an image converter (134).

5 29. Apparatus according to any of Claims 1-13, characterized in that the measuring head (40) comprises a measuring light source (160), where appropriate an optical system and at least one color filter (168) and a light detector (170).

10 30. Apparatus according to any of Claims 1-13, characterized in that the measuring device has a vibrator (144), a generator (146) operating on the vibrator, and means (148) for measuring the damping of the vibrator.

15 31. Apparatus according to any of Claims 1-13, characterized in that the measuring device has a vibrator (144), an intermittently operating generator (146) operating on the vibrator (144) and a receiver (144) for vibrations reflected from the tissue, and  
20 means (88) for evaluating the intensity of the reflected vibrations.

32. Apparatus according to any of Claims 1-13, characterized in that the measuring device has spaced electrodes (150, 152) which are connected to a resistance or impedance measuring unit (154) or represent  
25 part of a vibration circuit which is connected to a frequency measuring unit.

33. Apparatus according to any of Claims 1-13, characterized in that the measuring device has a micro-porous test tube (156) or a hollow drill whose interior  
30 can be connected to a negative pressure source (80).

34. Apparatus for assisting the remineralization of hard tissue, in particular carious dental tissue, characterized by a working head (40) which has sealing  
35 means (54) cooperating with the tissue surface, and is connected to at least one source (76; 176) of treatment medium.

35. Apparatus according to Claim 34, characterized in that the working head (40) can be connected inter-

*Claims 34-59 are cancelled*

mittently via a reversing valve (72) to a source (76) of treatment medium and an aspiration device (80).

36. Apparatus according to Claim 34 or 35, characterized in that the working head (40) has a hollow rod-like, preferably cylindrical delivery section (42) which is provided with at least one emergence orifice for treatment medium.

37. Apparatus according to Claim 36, characterized in that the delivery section (42) is closed at its free end, and the emergence orifices for the treatment medium are formed in the peripheral wall of the delivery section (42).

38. Apparatus according to any of Claims 34-37, characterized by a position indicator (48-52) for the axial position of the delivery section (42) in relation to the tissue surface.

39. Apparatus according to Claim 38, characterized in that the axial position indicator (48-52) has an input part (48) which cooperates with the tissue surface and which is arranged axially displaceably on the outer surface of the delivery section (42) and is supported by a spring (50) on a housing of the working head (40), a force or deformation sensor (52) being assigned to this spring.

40. Apparatus according to Claim 39, characterized in that the input part (48) of the position indicator (48-52) carries the sealing means (54).

41. Apparatus according to any of Claims 34-40, characterized in that the working head (40) is attached to a grip part (36), preferably in a manner rotatable about its long axis.

42. Apparatus according to Claim 41, characterized in that the long axes of the grip part (36) and working head (40) are inclined with respect to one another and preferably include an angle of about 30° to about 90°, once again preferably of about 60° with one another.

43. Apparatus according to Claim 42, characterized in that the grip part (36) is connected by a rotational joint to a supply cable.

44. Apparatus according to any of Claims 34-43, characterized in that at least one (176) of the sources (76, 176) of treatment medium has a storage container (176) inserted into the working head (40) or into the grip part (36) carrying the latter.

45. Apparatus according to any of Claims 34-44, characterized by a suction part (200) which can be placed at a distance from the working head on the surface of the tissue to be treated and can be connected to a suction device (80).

46. Apparatus for producing a working channel in hard tissue, in particular dental tissue, into which a probe section (42) of a measuring device according to any of Claims 2-33 or a delivery section of a treatment apparatus according to any of Claims 34-45 can be introduced, characterized by a drilling tool (30) whose outer diameter corresponds to the outer diameter of probe section (42) or delivery section (42), and by a drill drive (218) operating on this drilling tool (30).

47. Apparatus according to Claim 46, characterized in that the drill drive has an adjustable depth stop (220).

48. Apparatus according to Claim 46 or 47, characterized in that the diameter of the drilling tool (30) is between about 0.2 and about 1.0 mm, preferably between about 0.5 and about 0.8 mm.

49. Apparatus according to any of Claims 46-48, characterized in that the drilling tool (30) is hollow.

50. Apparatus according to any of Claims 46-49, characterized in that the drilling tool (286) is an ultrasonic drilling tool and is caused to vibrate in the direction of the drilling tool axis by an ultrasonic generator (282).

51. Apparatus according to Claim 50, characterized by a device (288) for supplying an abrasive fluid to the working surface of the ultrasonic drilling tool (286).

52. Apparatus according to any of Claims 46-51, characterized by an excavation tool (246) which has at

least one cutting edge (254) which is adjustable in the radial direction.

53. Apparatus according to Claim 52, characterized in that the radially adjustable cutting edge (254) is carried by a flute-like cutting tool (250) which is pivotably carried by a tool shaft (2468 [sic] whose outer diameter essentially corresponds to the outer diameter of the probe section (42).

54. Apparatus according to Claim 53, characterized in that the radius of curvature of the flute-like cutting tool (250) corresponds to the radius of the tool shaft (248).

55. Apparatus according to Claim 53 or 54, characterized in that the tool shaft (248) carries a plurality of, preferably two, linked cutting tools distributed in the radial direction.

56. Apparatus according to Claim 52, characterized in that the cutting edge is formed by a cut-out wall section (260; 296, 298) of a cylindrical tool shaft (248; 292) which can be moved radially outwards by friction or by structural means (260-264).

57. Apparatus according to Claim 52, characterized in that the radially adjustable cutting edges is [sic] arranged on an inflatable carrier (268) which is carried without leakage of flow medium by the end of a tubular tool shaft (248).

58. Apparatus according to Claim 57, characterized in that the inflatable carrier (268) is surrounded by a cutting layer (272) which forms a plurality of cutting edges and which is formed, for example, by a plurality of hard particles or diamond particles or is formed by a scrim of sharp-edged metal turnings or a metal lattice.

59. Diagnostic medium, in particular for use in an apparatus according to any of Claims 1-33, characterized in that it contains a marker substance which responds selectively to carious tissue and which is selected in relation to the measured tissue property.



60. Diagnostic medium according to Claim 59, characterized in that the marker substance comprises a coloring agent such as fuchsin, an X-ray contrast agent, a radionuclide [sic] or an electrolyte.

5 61. Treatment medium, in particular for use with an apparatus according to any of Claims 34-45, characterized in that it contains an antiseptic such as chlorhexidine.

10 62. Treatment medium, in particular for use with an apparatus according to any of Claims 33-45, characterized in that it contains an etchant such as EDTA or an aqueous phosphoric acid solution.

15 63. Treatment medium, in particular for use with an apparatus according to any of Claims 34-45, characterized in that it contains a primer such as, for example, an aqueous or organic acid solution.

20 64. Treatment medium, in particular for use with an apparatus according to any of Claims 34-45, characterized in that it contains a substance which dissolves organic tissue residues, such as, for example, sodium hypochloride [sic].

25 65. Treatment medium according to Claim 64, characterized in that it contains the substance which dissolves organic tissue residues in an amount of less than 6 percent by weight, preferably between about 1 and about 3 percent by weight.

30 66. Treatment medium, in particular for use in an apparatus according to any of Claims 34-45, characterized in that it contains a liquid settable substance or a substance which can temporarily be converted into the liquid state temporarily be converted into the liquid state. contains. [sic]

35 67. Treatment medium, in particular for use in an apparatus according to any of Claims 34-45, characterized in that it has inert particles.

68. Treatment medium according to Claim 67, characterized in that the particles comprise glass particles, calcium phosphate particles, ceramic particles, in particular  $\text{Al}_2\text{O}_3$  particles, hydroxyapatite particles,

fluorapatite particles, calcium fluoride particles, synthetic material particles, composite particles, salt particles, carbonate particles, fluorspar particles etc. or mixtures of the aforementioned particles.

5 69. Treatment medium according to Claim 68, characterized in that the average particle size of the particles is less than 50  $\mu\text{m}$ , preferably less than 20  $\mu\text{m}$ , once again preferably less than 10  $\mu\text{m}$  or 5  $\mu\text{m}$  and particularly preferably between about 0.5 and about  
10 2  $\mu\text{m}$ .

70. Treatment medium, in particular for use with an apparatus according to any of Claims 34-45, characterized in that it comprises components acting on the pulp.

15 71. Treatment medium, in particular for use with an apparatus according to any of Claims 34-45, characterized in that it comprises a remineralization-assisting, in particular fluoride-delivering component.

72. Treatment medium, in particular for use with an  
20 apparatus according to any of Claims 34-45, characterized in that it comprises a plurality of the components mentioned in Claims 59-71.

73. Diagnostic or treatment medium according to any of Claims 59-72, characterized in that it is contained  
25 in a deformable container (176) which has a plug connector part (178) with evident sealing.

74. Treatment article for use in a working channel (32) which has been produced with an apparatus according to any of Claims 46-58, characterized in that  
30 a treatment medium (239) is held by a basic article (234) whose outer diameter corresponds to the outer diameter of the drilling tool (30).

75. Treatment article according to Claim 74, characterized in that the basic article (234) consists  
35 of a porous material, preferably a sintered ceramic, calcium phosphate, hydroxyapatite, fluorapatite or synthetic material.

76. Treatment article according to Claim 74 or 75, characterized in that the treatment medium (239) has an

active substance linked to a resin material, which resin material in turn is carried by the basic article (234) or is enclosed in the latter or forms the basic article.

5 77. Treatment article for use in a working channel (32) which has been produced with an apparatus according to any of Claims 46-58, characterized in that it has a tubular shape, and its outer diameter corresponds to the outer diameter of the drilling tool  
10 (30), and has on its one end a releasable tight closure (244).

78. Treatment article according to Claim 77, characterized in that it consists of a fluid-tight material.

15 79. Treatment article according to Claim 77 or 78, characterized in that it has a conical head section (242) adjacent to the closure (242).

80. Treatment article according to any of Claims 74-79, characterized in that it is produced from  
20 a restoration material suitable for permanent incorporation, for example synthetic material, metal, ceramic, a composite material, polymer ceramic, a composition material, or a compomer material.

81. Apparatus according to Claim 14, characterized  
25 in that the fluid source (76; 80) is a positive pressure source which provides fluid with a positive pressure of from 0.1 to 0.8 bar, preferably 0.1 to 0.5 bar.

82. Apparatus according to any of Claims 1 to 45,  
30 characterized by means for exposing the diagnostic or treatment medium to sound or ultrasound.

83. Apparatus according to Claim 82, characterized by a supply part (42b), which is exposed to sound or ultrasound, for the diagnostic or treatment medium,  
35 which can be inserted into a working channel (32).

84. Apparatus according to Claim 83, characterized in that the supply part (42b) is hollow and its interior can be connected to a negative pressure source (80).

85. Apparatus according to any of Claims 1 to 45 or 81 to 83, characterized in that the working part (42) has an oscillating drilling tool (42a) which is preferably driven by ultrasound.

5 86. Apparatus according to Claim 83, characterized by a device (306, 308) for rinsing round the drilling tool (42b) with preferably abrasive working medium.

87. Diagnostic medium according to Claim 59 or 60, characterized in that it contains inert particles like  
10 those indicated for a treatment medium in any of Claims 67 to 69.

88. Diagnostic medium according to any of Claims 59, 60 or 87 or treatment medium according to any of Claims 61 to 73, characterized in that it  
15 contains at least one viscosity adjusting agent.

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